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Glyphosate Hinders Purple Nutsedge (*Cyperus rotundus*) and Yellow Nutsedge (*Cyperus esculentus*) Tuber Production

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The phase-out of methyl bromide requires alternative nutsedge management options in vegetable systems. Options that target tuber production, the primary means of reproduction, will be most beneficial. A study was conducted to evaluate the response of purple nutsedge and yellow nutsedge foliar growth and tuber production to a range of glyphosate rates. Glyphosate was applied at six rates between 0.41 and 2.57 kg ae ha^{-1} to 5-wk-old nutsedge plants with multiple shoots. The rate of glyphosate needed to reduce growth 50% (I_{50}) was similar for purple nutsedge foliar growth (0.58 kg ha^{-1}) and tuber biomass (0.55 kg ha^{-1}). In contrast, I_{50} for yellow nutsedge foliar growth was 0.73 kg ha^{-1}, which was greater than the I_{50} for tuber biomass (0.41 kg ha^{-1}). First-order tubers, those directly attached to the initial tuber, had an I_{50} of 0.70 and 0.44 kg ha^{-1} of glyphosate for purple nutsedge and yellow nutsedge tuber biomass, respectively. For all higher-order tubers, I_{50} values ranged from 0.29 to 0.60 and 0.14 to 0.30 kg ha^{-1} of glyphosate for purple nutsedge and yellow nutsedge tuber biomass, respectively. Glyphosate at 0.74 kg ha^{-1} prevented fourth-order purple nutsedge and third-order yellow nutsedge tuber production (terminal tubers for yellow nutsedge). Fifth- and sixth-order purple nutsedge tuber production was eliminated by the lowest tested rate of glyphosate (0.41 kg ha^{-1}). Effective nutsedge management options will require consistent control between spring and autumn crops. Glyphosate is economical, poses no herbicide carryover issues to vegetables, and minimizes nutsedge tuber production; therefore, it is a suitable candidate to manage nutsedges.
Nomenclature: Glyphosate; purple nutsedge, *Cyperus rotundus* L. CYPRO; yellow nutsedge, *Cyperus esculentus* L. CYPES.
Key words: Methyl bromide alternative, perennial weed, tuber, vegetable production.

Purple and yellow nutsedge are the most troublesome weeds of cucurbit and fruiting vegetable crops in the southern United States (Webster 2006; Webster and MacDonald 2001). Methyl bromide has been used to manage nutsedges in polyethylene mulch-covered beds in southeastern U.S. vegetable production. However, because of its ozone-depleting properties, use of methyl bromide as a preplant fumigant has been eliminated, with the exception of critical use exemptions approved by the United Nations. The inconsistent nutsedge efficacy of proposed methyl bromide alternatives in cucurbits and fruiting vegetables (Culpepper and Langston 2004, 2005; Gilreath and Santos 2005; Gilreath et al. 2004; 2005; Webster et al. 2001) coupled with the prolific reproduction capability of nutsedges (Webster 2005) will force growers to aggressively manage nutsedge populations with herbicides (Dusky and Stall 1996; Fennimore et al. 2001; Haar et al. 2002; Johnson and Mullinix 2002, 2005; Webster and Culpepper 2005). In addition to the ability to reduce crop yields (Johnson and Mullinix 1999; Kadir et al. 1999; Morales-Payan et al. 1997; Motis et al. 2003, 2004; Santos et al. 1997), nutsedges will affect mulch integrity, a significant concern for growers who use the same mulch for multiple crops. Also, nutsedges may interact with other pests to increase their severity and complicate management (Davis and Webster 2005; Martinez-Ochoa et al. 2004; Thomas et al. 1997, 2004, 2005).

Purple and yellow nutsedges have been documented to produce achenes from aerial inflorescences. However, there were low rates of viability for purple nutsedge achenes (less than 5%), whereas yellow nutsedge achenes had 50 to 90% germination (Justice and Whitehead 1946). In agricultural fields, both nutsedge species reproduce primarily by underground tubers (Wills 1987); therefore management of nutsedges should focus on reducing tuber development and viability. Glyphosate and paraquat are commonly used, nonselective herbicides applied to control weeds in vegetable row middles and before planting crops in production systems with mulch-covered beds. Paraquat results in excessive cell destruction of existing nutsedge foliage in the presence of sunlight, but foliar regrowth was rapid and tuber production was not affected because of limited paraquat translocation (Mercado 1979; Wood and Gosnell 1966; Zandstra et al. 1974). In contrast, previous research indicated that glyphosate was translocated through chains of purple nutsedge tubers, which reduced tuber viability and production (Doll and Piedrahita 1982; Zandstra et al. 1974). However, glyphosate rates used in these studies were two to four times greater than current use rates. Glyphosate is recommended for managing nutsedges produced with and without polyethylene mulches (Culpepper 2006) and has successfully reduced nutsedge tuber populations in other cropping systems (Bryson et al. 2003; Charles 1997; Edenfield et al. 2005). However, no previous studies have described, at the individual plant level, the effect of glyphosate on the dynamics of new tuber production in mature plants. The objective of this study was to quantify the effect of various glyphosate rates on foliar control and tuber production in established purple nutsedge and yellow nutsedge plants.

Materials and Methods

Greenhouse studies were conducted between February 2003 and June 2003 at the Coastal Plain Experiment Station in Tifton, GA. The greenhouse conditions consisted of natural light supplemented with metal halide lamps (300 μmol m^{-2} s^{-1} photosynthetic photon flux) with average day/night temperatures of 32/24 C. Experimental units consisted of 30-cm-diam circular pots that were 16 cm tall

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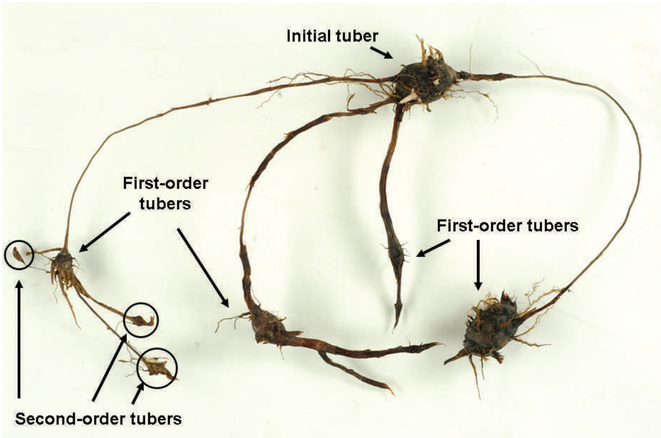

Figure 1. Purple nutsedge tuber system illustrating the relationship between the initial tuber, first-order tubers, and second-order tubers.

(11.3 L). Pots of this depth were selected because previous research indicated that 99% of purple nutsedge tubers were distributed within 16 cm of the soil surface (Siriwardana and Nishimoto 1987). Pots were filled with sifted, sterilized Tifton loamy sand (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults) consisting of 86% sand, 7% clay, and 7% silt with pH 6.1 and 0.5% organic matter.

Tubers with a biomass of 1.10 g for purple nutsedge and 0.21 g for yellow nutsedge were planted in seedling trays with 128 cells (3.8 cm diam by 6.4 cm deep) containing Tifton loamy sand. Purple nutsedge tubers were obtained from a local naturalized population in Tifton, GA; yellow nutsedge tubers were obtained from a commercial source.[1] One tuber with a single shoot (9 to 11 cm in length) was transplanted into each experimental unit 3 wk after tubers were planted in seedling trays. The experiment was arranged as a randomized complete block design with five replications and repeated over time. Pots were watered twice daily and fertilized weekly with 40 ml of a 7.9 g L^{-1} solution of 20-20-20. Nutsedge shoot emergence was monitored and new shoot emergence marked daily after planting with date of soil surface protrusion using a plastic sheath (0.3 to 0.5 cm length) slid to the base of the shoot (Webster 2005).

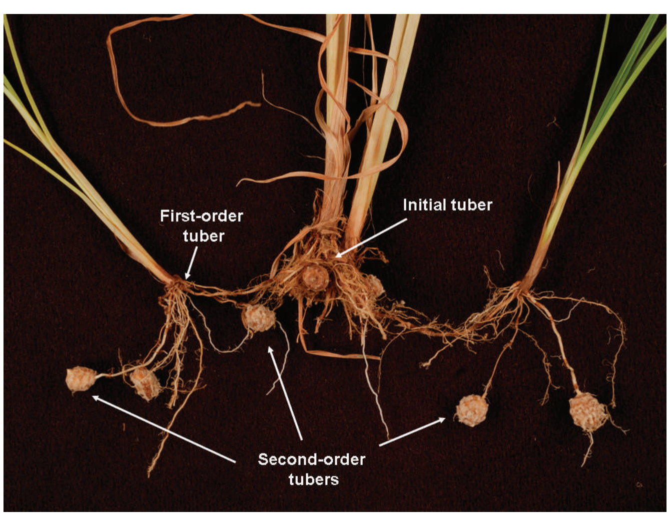

Figure 2. Yellow nutsedge tuber system illustrating the relationship between the initial tuber, first-order tubers, and second-order tubers.

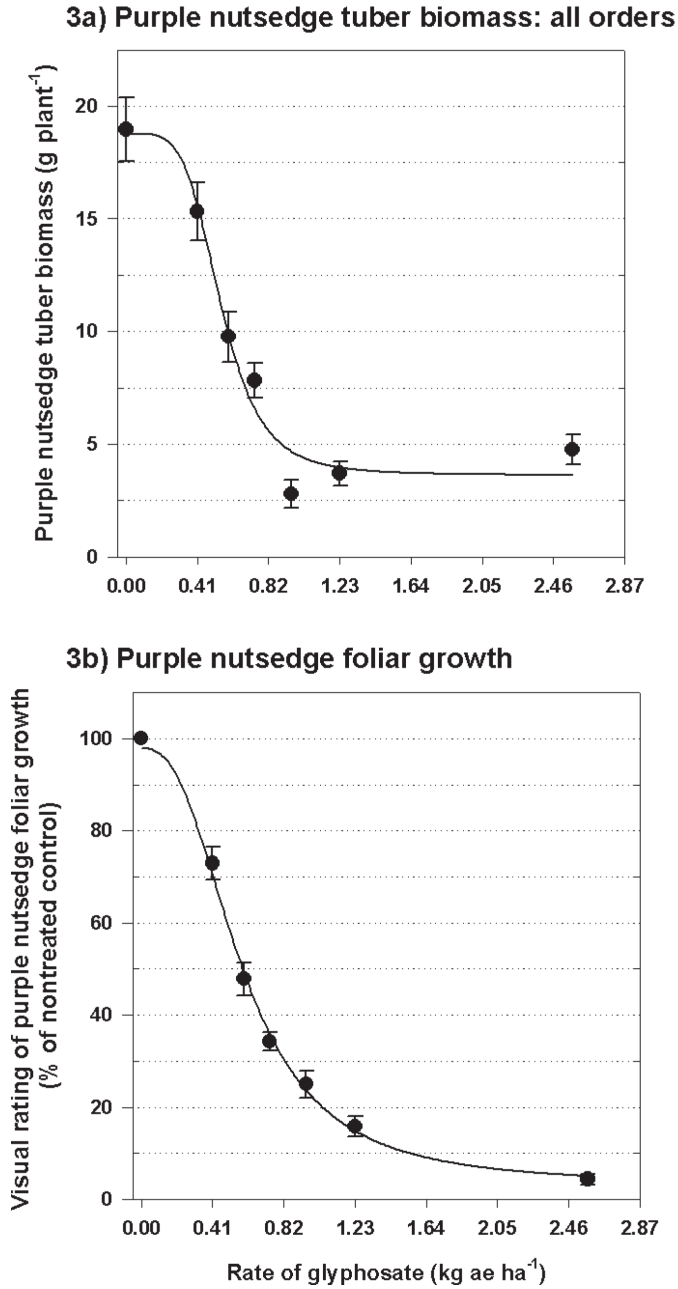

Figure 3. The relationship between (a) purple nutsedge total tuber biomass and glyphosate rate and (b) purple nutsedge foliar growth and glyphosate rate. The I_{50} and b parameter estimates are found in Table 1.

Five wk after nutsedge transplanting, isopropylamine salt of glyphosate was applied. The transplanted purple nutsedge averaged 22.4 cm in height with 4.4-cm shoots, and yellow nutsedge was 40 cm in height with 10-cm shoots. All shoots emerged at the time of glyphosate application were from the initial tuber or were first-order shoots (Figures 1 and 2). Glyphosate was applied at 0.41, 0.59, 0.74, 0.95, 1.23, and 2.57 kg ae ha^{-1}. A nontreated control was included for comparison for purple and yellow nutsedge. Applications were made using a CO_2-pressurized backpack sprayer calibrated to deliver 187 L ha^{-1} at 133 kPa.

Visual foliar growth ratings were evaluated relative to the nontreated control at 4 wk after glyphosate application using a scale of 0 (plant death) to 100 (similar to nontreated

Table 1. Parameter estimates for the I_{50} and slope (b) of the regression describing the relationship between foliar growth or tuber biomass and rate of glyphosate for each tuber order of purple and yellow nutsedge.

	Order[a]	I_{50} (SE)	b (SE)	R^2	P value
Purple nutsedge		kg ha^{-1}			
Foliar growth	All	0.58 (0.02)	2.59 (0.29)	0.96	< 0.0001
Tuber biomass	All	0.55 (0.03)	4.66 (1.09)	0.82	0.0001
	0[b]	—	—	—	—
	1	0.70 (0.05)	8.20 (5.0)	0.50	< 0.0001
	2	0.66 (0.04)	6.69 (2.8)	0.67	< 0.0001
	3	0.33 (0.07)	3.54 (2.9)	0.81	< 0.0001
	4	0.29 (0.24)	3.75 (9.9)	0.75	< 0.0001
Yellow nutsedge					
Foliar growth	All	0.73 (0.04)	2.39 (0.32)	0.92	< 0.0001
Tuber biomass	All	0.41 (0.05)	3.07 (1.4)	0.59	< 0.0001
	0	1.17 (0.34)	4.12 (3.9)	0.14	0.0207
	1	0.44 (0.06)	3.47 (1.6)	0.55	< 0.0001
	2	0.30 (0.11)	2.26 (2.1)	0.51	< 0.0001
	3	0.14 (0.37)	1.80 (4.8)	0.58	< 0.0001

[a] Order refers to the relative position of the tuber to the initial tuber. First-order tubers were attached directly to the initial tuber, the second-order tubers were attached to first-order tubers, and third-order tubers attached to second-order tubers.

[b] There was no effect of glyphosate rate on tuber biomass of the initial purple nutsedge tuber; therefore regression could not be fit to the data.

control). Studies were concluded 5 wk after glyphosate application, 10 wk after test establishment. Wire mesh (7.8 holes cm^{-1}) was stretched across a wooden frame to sieve and separate the tubers from the soil. Data collected included individual tuber and shoot number and dry biomass. The growth habit of purple nutsedge has been previously characterized as a chain of tubers (Wills 1998). All data were separated into categories on the basis of their relative position to the initial tuber, as previously described (El-Masry and Rehm 1976, 1977). Tubers that were attached directly to the initial tuber were termed first-order tubers (i.e., first generation from the initial tuber). Second-order tubers were attached to first-order tubers (Figures 1 and 2). Sixth- and third-order tubers were terminal for these experiments for purple nutsedge and yellow nutsedge, respectively.

Data were subjected to ANOVA by nutsedge species and tested for experiment-by-glyphosate treatment interactions. No experiment-by-treatment interactions were noted, so data were combined across experiments. Nutsedge tuber biomass and foliar control data for each species were regressed on glyphosate rate and the log-logistic dose response model fit to the data (Seefeldt et al. 1995). The regression model was:

$$y = c + \left(\frac{d - c}{1 + \left(\frac{x}{I_{50}} \right)^{b}} \right) \qquad [1]$$

where c is the mean response at the highest herbicide rate, d is the mean response of the nontreated control, I_{50} is the herbicide rate that provides 50% response, and b is the slope of the curve around I_{50}. The I_{50} parameter estimates for foliar control and tuber biomass were compared using t tests (Glantz and Slinker 2001; Webster et al. 2004).

Results and Discussion

There were glyphosate rate-by-nutsedge species interactions, but no glyphosate rate-by-trial interactions for purple or yellow nutsedge tuber biomass. Therefore, data were combined over trials and analyzed by nutsedge species.

Purple Nutsedge. In the nontreated control, a single purple nutsedge tuber produced 34 tubers that totaled 18.8 g after 10 wk of growth. Foliar growth and tuber biomass of purple nutsedge were reduced with increasing rates of glyphosate (Figure 3). Glyphosate at 2.57 kg ha^{-1} reduced purple nutsedge foliar growth and total tuber biomass 95 and 75%, respectively. Total purple nutsedge tuber biomass was reduced 50% (I_{50}) by glyphosate at 0.55 kg ha^{-1}, as estimated from the logistic regression (Table 1). This was similar to the I_{50} for purple nutsedge foliar growth, 0.58 kg ha^{-1} of glyphosate (t = 0.83). Previous research indicated that the I_{50} for visual control of purple nutsedge foliage in greenhouse studies ranged from 0.27 to 0.43 kg ha^{-1} of glyphosate (Culpepper et al. 2004; Molin and Hirase 2004); however, plants in these studies had less than seven leaves at the time of application, whereas the plants in the current study were larger and had multiple emerged shoots. This conclusion is consistent with the research of Suwunnamek and Parker (1975), which demonstrated that foliar regrowth after glyphosate application was dependent

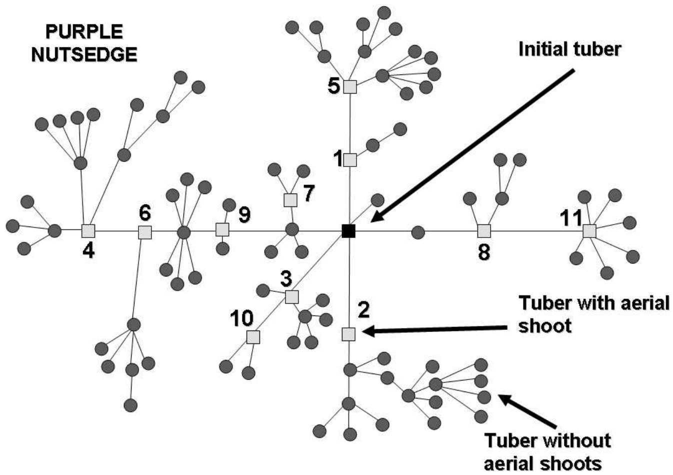

Figure 4. Growth schematic of a purple nutsedge plant after 15 wk of growth, originating from a single tuber. Boxes indicate tubers with aerial shoots (i.e., basal bulbs). The numbers adjacent to the boxes indicate the relative order of shoot emergence. Circles indicate tubers without aerial shoots. Each aerial shoot represents approximately four tubers.

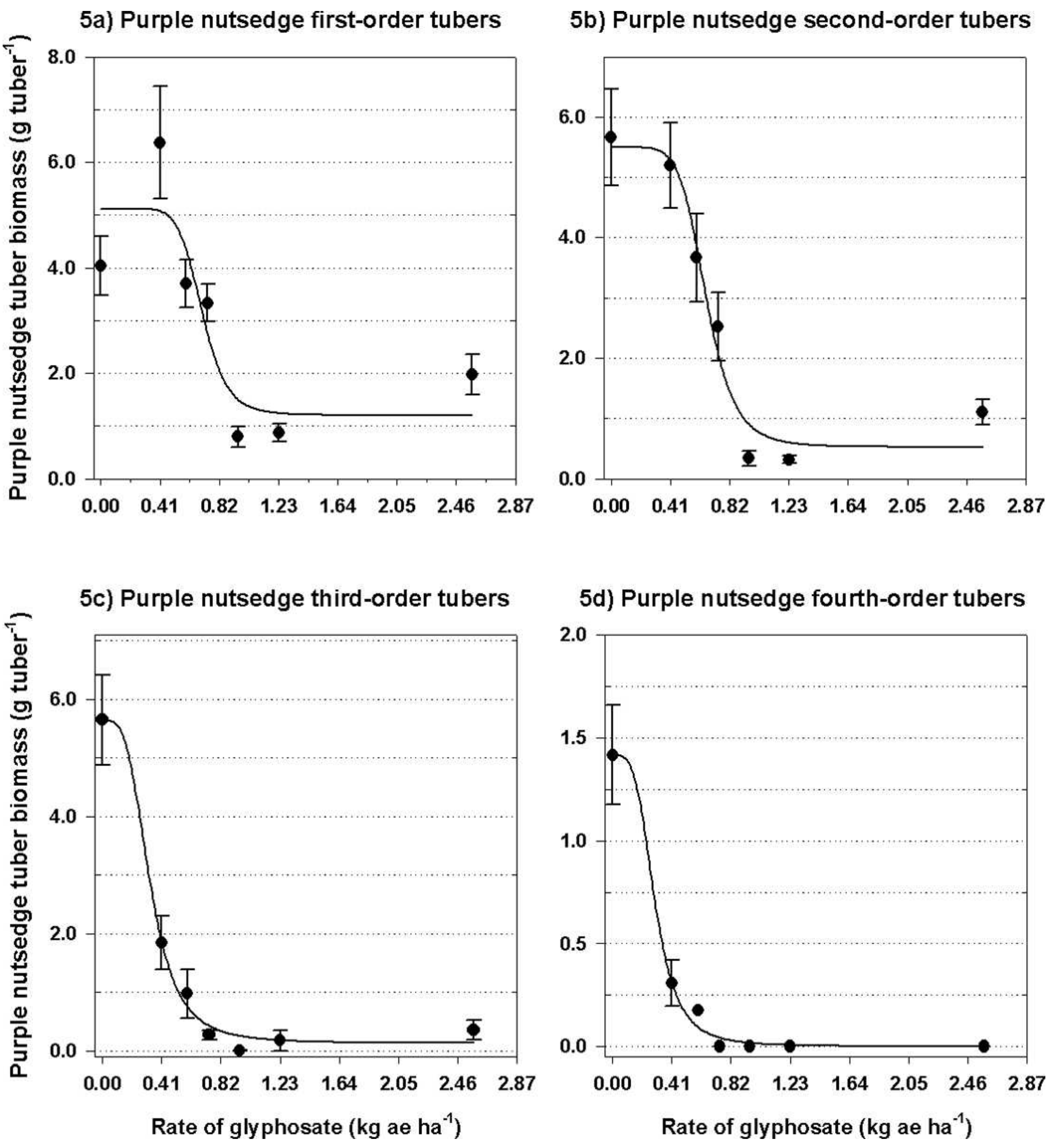

Figure 5. The relationship between purple nutsedge tuber biomass and glyphosate rate for first through fourth orders. The I_{50} and b parameter estimates are found in Table 1.

upon purple nutsedge size at the time of application. Akin and Shaw (2001) determined that multiple applications of glyphosate (0.42 kg ha^{-1} followed by 0.28 kg ha^{-1} 2 wk later) controlled purple nutsedge foliage 74%, but only reduced tuber population density 42%. Other research determined that glyphosate at 2 and 4 kg ha^{-1} reduced purple nutsedge population density 26 and 66%, respectively, relative to the nontreated control (Zandstra et al. 1974). It is not clear how severely injured foliage were considered when stand density was quantified in the Zandstra et al. (1974) study. Research in soybean [*Glycine max* (L.) Merr.] demonstrated that a single application of 1.1 kg ha^{-1} glyphosate controlled purple nutsedge foliage 93% at 40 d after planting and reduced tuber population densities 60% (Edenfield et al. 2005). When this rate was applied in the same plots in the second and third year, foliage was controlled at least 92% and tuber population densities were reduced 86 and 100% relative to the nontreated control, respectively (Edenfield et al. 2005).

Classification and analysis of tubers on the basis of their relative proximity to the initial tuber (Figure 4) revealed a differential influence of glyphosate rate on tuber dynamics. In the absence of glyphosate, approximately 30% of the total tuber biomass occurred within the second- and third-order tubers, 21% in first-order tubers, 7% in fourth-order tubers, and 3% in a combined category of fifth- and sixth-order tubers. Average tuber size decreased as tuber orders increased; average tuber biomass in the nontreated control ranged from 0.74 g tuber^{-1} for first-order tubers to 0.33 g tuber^{-1} for fifth- and sixth-order tubers.

There was no effect of glyphosate rate on tuber biomass in the initial tuber; tuber biomass of the parent tuber at 5 wk after treatment was 1.70 and 1.67 g in the nontreated control and glyphosate at 2.56 kg ha^{-1} treatments, respectively, each with approximately 50% more biomass than when planted (data not shown). There was a response to glyphosate in first-order tubers. Glyphosate at 0.41 kg ha^{-1} increased first-order tuber biomass 64% relative to the nontreated control (Figure 5a). Previous research has documented an increase in plant growth to low rates of glyphosate (Brain and Cousens 1989). The estimated I_{50} from the logistic regression was 0.70 kg ha^{-1} of glyphosate (Table 1). This is a slightly greater (t = 2.57) glyphosate rate than required to reduce the total purple nutsedge tuber biomass, indicating that first-order tubers were more tolerant to glyphosate than other orders, perhaps due to their larger size.

Glyphosate applied at 0.59 kg ha^{-1} and greater reduced second-order purple nutsedge tuber biomass 35 to 95% relative to the nontreated control (Figure 5b). The I_{50} parameter estimate was 0.66 kg ha^{-1} of glyphosate, which was similar (t = 0.62) to the I_{50} for first-order tuber biomass (Table 1). These results indicate that second-order purple nutsedge tubers were likely formed, but still developing, at the time of glyphosate application. This is supported by the low average tuber biomass of 0.054 and 0.046 g tuber^{-1} due to glyphosate at 0.95 and 1.23 kg ha^{-1}, respectively, compared with the nontreated control (0.65 g tuber^{-1}). Previous research indicated that nutsedge tuber longevity was related to tuber size (Siriwardana and Nishimoto 1987; Thullen and Keeley 1975). In addition, Stoller et al. (1972) found a positive correlation between nutsedge foliar biomass and tuber size, which would likely have an impact on the competitiveness of treated nutsedge plants.

Third-order purple nutsedge tubers were produced in all glyphosate treatments, likely indicating that production of third-order tubers were initiated before glyphosate application at 5 wk after transplanting the initial tuber and emerged shoot (Figure 5c). The estimated I_{50} for third-order tuber biomass was 0.33 kg ha^{-1} of glyphosate, which is lower than I_{50} for first-order (t = 4.34), second-order (t = 4.13), and total (t = 2.88) tuber biomass (Table 1). Relative to the nontreated control, the lowest rates of glyphosate reduced third-order purple nutsedge tuber biomass 67%.

Fourth-order tubers were produced in plants treated with glyphosate at 0.41 and 0.59 kg ha^{-1}, but with at least 78% less biomass than the nontreated control (Figure 5d). All other rates of glyphosate prevented the formation of fourth-order purple nutsedge tubers, indicating that this may have been the threshold of new tuber production at the time of glyphosate application. The I_{50} estimate for fourth-order tuber biomass was 0.29 kg ha^{-1} of glyphosate (Table 1). However, the lack of nonzero data for this order may have affected the accuracy of this parameter estimate. All rates of glyphosate prevented formation of fifth- and sixth-order purple nutsedge tubers (data not shown).

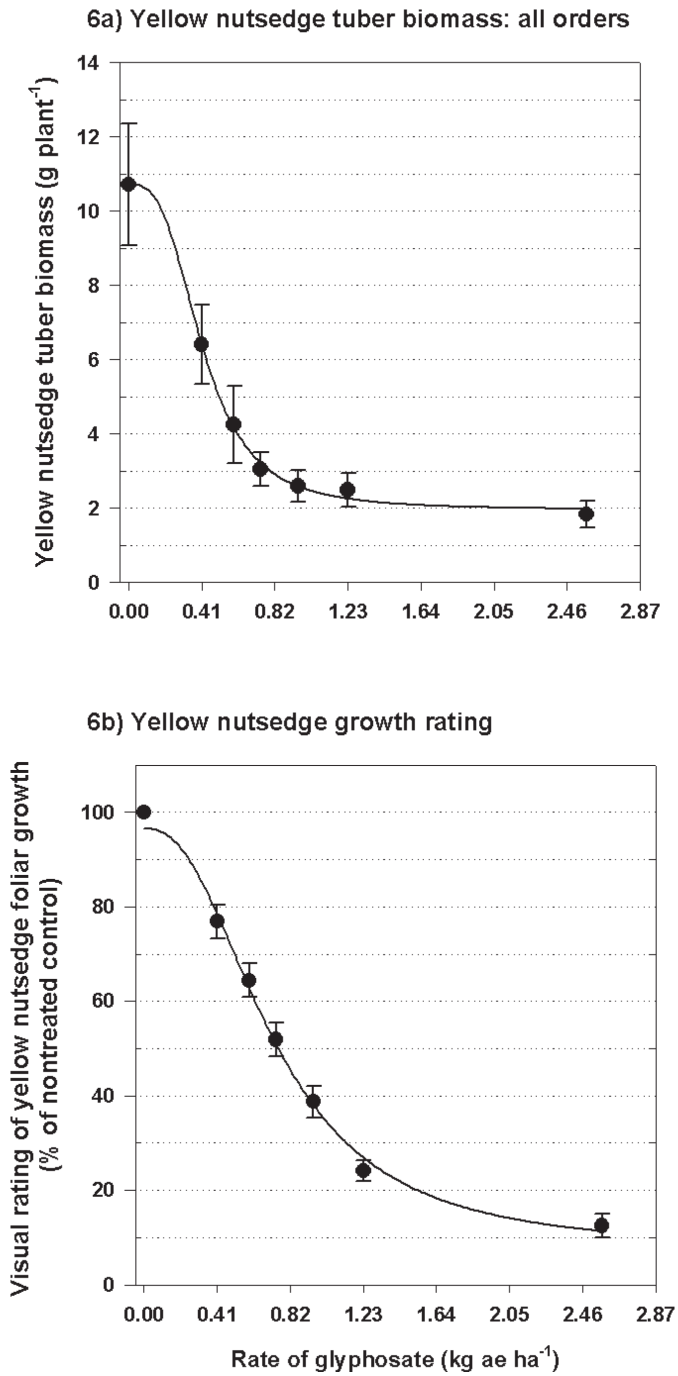

Figure 6. The relationship between (a) yellow nutsedge total tuber biomass and glyphosate rate and (b) yellow nutsedge foliar growth and glyphosate rate. The I_{50} and b parameter estimates are found in Table 1.

Yellow Nutsedge. In the nontreated control, a single yellow nutsedge plant produced 49 tubers that totaled 10.8 g after 10 wk of growth. Glyphosate at 0.41 kg ha^{-1} reduced yellow nutsedge foliar growth 23%, whereas this rate reduced total tuber biomass 51% relative to the nontreated control (Figure 6).

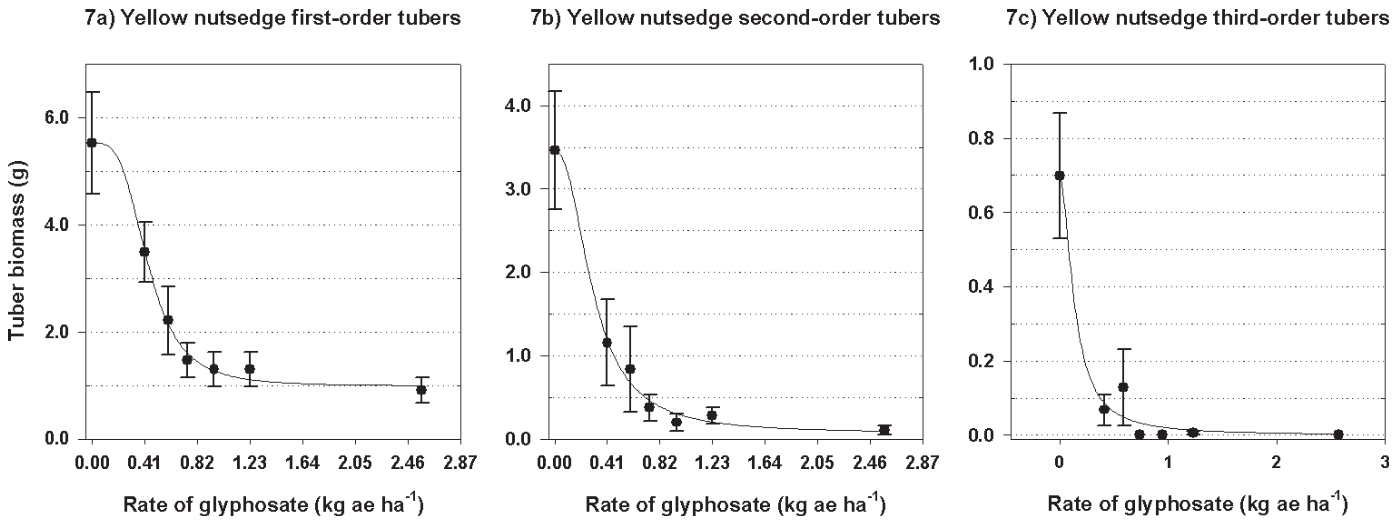

Figure 7. The relationship between yellow nutsedge tuber biomass and glyphosate rate for first through third orders. The I_{50} and *b* parameter estimates are found in Table 1.

The I_{50} for foliar growth suppression was 0.73 kg ha^{-1}of glyphosate, whereas yellow nutsedge total tuber biomass required less (t = 5.0) glyphosate (0.41 kg ha^{-1}) (Table 1). This indicates that yellow nutsedge tuber production was more sensitive to glyphosate than was the foliar growth response, which differs from what was observed for purple nutsedge where tuber biomass and foliar growth had similar I_{50} values. Previous research has shown that the I_{50} for yellow nutsedge foliar control ranged from 0.25 to 0.54 kg ha^{-1} of glyphosate, but plants in the previous studies were single shoots that were $<$20 cm in height at the time of application (Culpepper et al. 2004; Faircloth et al. 2004; Nelson et al. 2002). This also confirms previous research (Culpepper et al. 2004; Swann 2000) in demonstrating that purple nutsedge foliar growth was more (t = 3.35) sensitive to glyphosate than yellow nutsedge foliar growth (Table 1). The influence of glyphosate rate on yellow nutsedge tuber production per plant has not been previously evaluated.

In the nontreated control, 52, 32, and 7% of the total tuber biomass were first-, second-, and third-order tubers, respectively. Biomass of the initial tuber at the conclusion of the study was 1.03 g tuber^{-1} in the nontreated control, nearly fivefold larger than when planted. Of the newly produced tubers, first-order tubers were the largest (0.27 g tuber^{-1}), with smaller tubers in second (0.20 g tuber^{-1}) and third orders (0.12 g tuber^{-1}).

There was no effect of glyphosate rate on biomass of the initial yellow nutsedge tuber, with the exception of the lowest rate of glyphosate that increased tuber biomass 65% compared with the nontreated control (data not shown). Glyphosate reduced first-order yellow nutsedge tuber biomass 37% relative to the nontreated control (Figure 7a). The estimated I_{50} for first-order yellow nutsedge tuber biomass was 0.44 kg ha^{-1} of glyphosate, similar to that for yellow nutsedge tuber biomass summed across all orders, but lower (t = 3.63) than that for first-order purple nutsedge tuber biomass (Table 1).

Yellow nutsedge in all treatments possessed second-order tubers, indicating that tubers were likely present at the time of glyphosate application. Plants treated with glyphosate at 0.41 kg ha^{-1} had 67% less second-order tuber biomass than the nontreated control, but 4 to 11 times more tuber biomass than plants treated with glyphosate 0.95 kg ha^{-1} or greater. The estimated I_{50} for second-order yellow nutsedge tuber production was 0.30 kg ha^{-1} of glyphosate, which was similar (t = 0.72) to I_{50} for total yellow nutsedge tuber biomass summed over all orders, but lower (t = 3.08) than that for second-order purple nutsedge tuber biomass (Table 1). Yellow nutsedge plants produced third-order tubers when treated with glyphosate; however, biomass was reduced at least 82% by glyphosate at 0.59 kg ha^{-1} (Figure 7c). All other glyphosate treatments prevented third-order tuber production for yellow nutsedge. The estimated I_{50} for third-order yellow nutsedge tuber biomass was 0.14 kg ha^{-1} of glyphosate (Table 1).

Several reports of the variability of yellow nutsedge have focused on aboveground morphological characteristics (Holt 1994; Schippers et al. 1995; Tayyar et al. 2003) or genetic characteristics (Holt 1994; Okoli et al. 1997; Tayyar et al. 2003), but no studies have evaluated variability of tubers across populations. One characteristic commonly associated with yellow nutsedge, and used as an identifying feature, is the presence of terminal first-order tubers (Mulligan and Junkins 1976). Presence of terminal first-order tubers was suggested as the mechanism that limits the lateral spread of yellow nutsedge from the initial tuber (Schippers et al. 1993). Jansen (1971) demonstrated that yellow nutsedge could form a complex system that included small tuber chains. Rhizomes originating from basal bulbs of yellow nutsedge were capable of forming subsequent basal bulbs, resulting in secondary, tertiary, and higher-order vegetative shoots that were all able to form rhizomes with tubers (Jansen 1971). Yellow nutsedge plants used in the current study also possessed higher-order tubers and vegetative shoot (Figures 2 and 8).

Previous studies of nutsedge anatomy have separated subterranean structures into tubers and basal bulbs (Wills and Briscoe 1970; Wills et al. 1980). A basal bulb is the source of vegetative shoots within a growing season; however, these structures do not accumulate starch (Wills et al. 1980); therefore vegetative shoots the following season typically arise from tubers (Jansen 1971). In yellow nutsedge, a mixture of tubers and basal bulbs occurred in first and second orders, with only tubers represented in the third order (Figure 8). In contrast, purple nutsedge had a mixture of tubers and basal

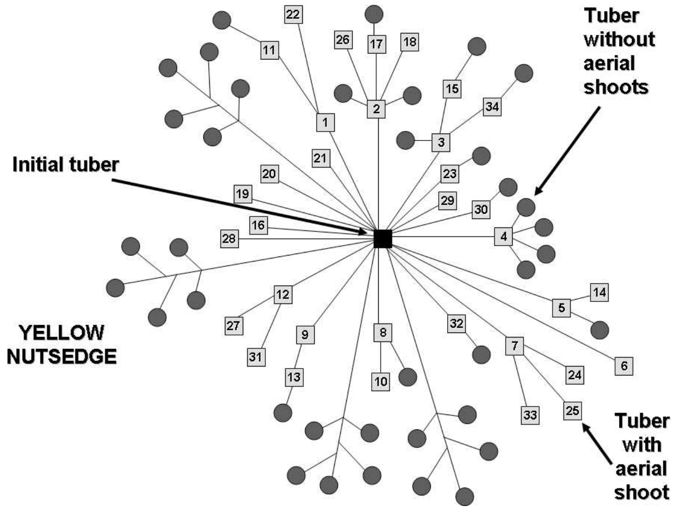

Figure 8. Growth schematic of a yellow nutsedge plant after 15 wk of growth, originating from a single tuber. Boxes indicate tubers with aerial shoots (i.e., basal bulbs). The numbers within the box indicate the relative order of shoot emergence. Circles indicate tubers without aerial shoots.

bulbs in the first four orders with tubers (or nondifferentiated basal bulbs) occurring in the fifth and sixth orders (Figure 4).

In summary, glyphosate is an effective means of reducing tuber biomass production in purple and yellow nutsedge. Purple nutsedge tuber biomass was reduced 48% by glyphosate at 0.59 kg ha^{-1}, whereas this rate reduced yellow nutsedge tuber biomass 60%. The highest tested glyphosate rate (2.57 kg ha^{-1}) reduced purple and yellow nutsedge tuber biomass 75 and 83% of the nontreated control, respectively. Glyphosate at 0.74 kg ha^{-1} prevented fourth-order purple nutsedge tuber production and third-order yellow nutsedge tuber production. Fifth- and sixth-order purple nutsedge tuber production was eliminated by the lowest tested rate of glyphosate (0.41 kg ha^{-1}).

The complexity and difficulty of managing nutsedges in vegetable crops will increase with the elimination of methyl bromide (Harrison and Fery 1998). Vegetable production systems of the Southeast United States have long relied on methyl bromide to manage multiple pests (Ragsdale and Wheeler 1995), including nutsedge species. Successful management of nutsedges in the absence of methyl bromide will require diligent control programs before crop planting, during the cropping season with methyl bromide alternatives, and between spring and autumn crops. Glyphosate will be an important component of these management programs, especially since glyphosate will hinder tuber production, the primary means of reproduction for purple and yellow nutsedges. Effective long-term management nutsedge programs will require repeated consistent control, as the estimated longevity of purple nutsedge tubers (99% tuber mortality) is 42 mo (Neeser et al. 1997); yellow nutsedge tubers survived at least 6 yr in agricultural fields where new tuber formation was prevented over the course of the study (Rotteveel and Naber 1993).

Sources of Materials

[1] Yellow nutsedge tubers, Azlin Seed Service, 112 Lilac Dr., Leland, MS 38756.

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